Pa0nhc ARDFrx2.2 PCB 20180123-14 v. 20180203

Schematic details.

An effective and supple gain adjustment is realized by varying the g2 voltages of IF amplifier Fets 1 and 4. The needed negative and positive voltages (abt. -0.35Vdc to abt. +0.63 Vdc) are generated by the voltage drops over D1 and D2.

REM: as the full battery current runs through D2, this diode will be damaged in case of an accidental short circuit from B+ to a PCB ground surface.

IC1 needs no gain adjustment. This enhances oscillator stability and VHF large signal capacity.

This receivers good sensitivity is accomplished by an optimal match and low insertion loss of the **antenna input circuit.** In practice, when a 50 Ohms dummyload is connected, and short circuited, the level of IC1 input noise is changing, indicating good sensitivity.

A more complicated optimal selective RF input 145 MHz filtering (like a 3-stage helix filter) is unpractical here. It needs more space, is heavier, costs more and has more insertion loss.

The impedance transformation ratio of the antenna circuit should be 50 : 1500. The voltage transformation should therefore be 1 : 5.5. As a consequence, a link or tap coupling to L1 could not be used. The single high-Q coil L1 has low losses. **An 145 MHz antenna circuit with good match to 50 Ohms, was not achievable with a ring core coil.**

In stead, an exactly dimension able capacitive voltage divider is used, resulting in always perfect match. If tuning to resonance should be done with a trimmer capacitor, the transformation ratio changes during tuning. L1 is therefore tuned for resonance by its ***core***.

REM: if for L1 a coil with different inductance is used, the value of C1 and C2 should be changed to be able to tune to 144.5 MHz, but still should have a capacitance ratio of abt. 6.5 : 1 .

R1 bleeds static's, preventing damage to C1 and IC1.

Mirror reception of short burst of air traffic around 124.1 MHz is less annoying than continues reception of very strong pager transmitters around 165.9 MHz. And a free running 133.5 MHz oscillator is more stable than an nearly equal 156.2 MHz oscillator. **So i decided for "Under mixing", with a local oscillator frequency below the receiving frequency, around 133.5MHz.**

The double sided, precisely designed PCB, results in no de-sensibilisation, nor ghost signal reception from both low power oscillator circuits. Thanks to the optimal separation between circuit blocks, visible in the length-wise PCB layout, which also makes a cheap home made housing of ALU tube possible.

De-coupling capacitor C3 (100pF, SRF 100 - 180 MHz) and choke L15 (1uH SRF 180MHz) are effective for VHF signals. The 22nF (SRF 8-17 MHz) capacitors and 22uH (SRF 11 MHz) chokes are optimal for filtering 10.7 MHz IF signals. But only if their connecting wires and traces are of minimal length.

Audio IC2, buffer stage FET102/103 and sense amplifier FET101 are powered directly from the battery. All other (more critical) circuits are powered from a stable +5V. Resulting in a very stable tuning (as for a free running 135 MHz oscillator without temperature compensation) and stable gain adjustment. Low drop stabilizer Vr1 acts here as a very good circuits separator.

The LED is a simple but effective battery condition indicator. It darkens when the battery voltage runs down to 6V, warning that the tuning and gain adjustment can become unstable.

IF coils L3 and L6 are standard available Neosid coils. You could wind these coils yourself by winding abt. 20 turns 0.3mm wire on an screened Neosid bobbin type 7F1S. The coils are not damped by resistors R27/28, nor by the high input and output impedances of MOSfets 1 and 4.

Resulting in a high amplification factor and selectivity. Different coil types for L3/L6 can result in different stage amplification. **With RF-full gain, the receivers self noise should generate abt. 0.3Vrms at R19.** This can be changed by changing the audio amplification, changing the values of R15/C34 and R18/C35 to correct it. The holes here are wide to make this easy.

The total wide band selectivity from the crystal filter + IF coils is very good, and IC1 only starts blocking at a very high input level of S9+60dB.

In practice, a distant and very weak fox hunt transmitter can be received without problems, even standing in the vicinity of a strong finish-fox-transmitter.

Depending on the filter crystals used, an extra capacitor (0.5-1.5pF), connected from the input of F2 to ground, could change the crystal filter band pass curve, and/or the far away selectivity.

The values of Rx and Ry depend on the type of the used crystal filter.

Resistors R30 and R33 in the g2 circuits of the MOSfets, discourage parasitic VHF/UHF oscillations.

Audio filter stage.

Direction finding receivers should NOT have automatic gain control. But this can result in a danger :
BE AWARE: a suddenly active strong transmitter could be ear damaging loud when listening to a distant weak transmitter on the same frequency.

Even the "plop", when from switching the receiver on-off, can be far to loud.

You MUST reduce the **maximal loudness** from YOUR used headphone to 85dBspl, by adapting the resistive value of R20.

Resistors R31 and R32 have a double function : they act as audio attenuators AND help block RF, which could be induced onto the head phone cord. The values of these resistors depend on the sensitivity of the used head phone. **See “Setup”. Their holes are made wide for easy change.**

The **AM detector circuit** around Fet5 is of the "Infinite Impedance" type.

Its positive properties are :
- simple circuit,
- low distortion
- good performance at very low input levels
- high impedances, no RF damping
- low current consumption.

Fet5 should be a low IDss Jfet (BF256b). It is set to class B by means of high value resistor R22.

The 10.7 MHz BFO oscillator T1 injects a little signal for demodulation of CW and SSB signals.

SPECIAL : this injected BFO signal acts as a bias for FET5, vastly enhancing its sensitivity and lowering its distortion. The value of C207 sets the injection level.

If you only want to detect AM signals, then order a 10.670 MHz crystal for Xt. The crystal oscillator is still needed for enhancing the sensitivity of the Jfet detector, but it will not cause interference tones. Due to the fact that its frequency falls outside the total IF bandwidth, and remaining weak interference falls outside the audio pass band.

As even with very low input voltages the signal distortion in the detector circuit is very low, and the IF coils are high-Q, resulting in high stage gain, a third IF amplifier stage could be omitted, lowering power consumption. **The remaining needed gain is solely delivered by the audio filter/amplifier stage IC2.** Reducing the number of components, needed PCB space, and current consumption.

Audio IC2 has 5V capabilities and rail-to-rail output. It has hiZ FET inputs, and will not load the Jfet demodulator. Its two stage gain can be over 60dB (!), still having ample negative feedback. Its surrounding components **reduce the audio bandwidth from 150 Hz to 1.5 kHz** with both 18 dB/oct filter slopes. Enhancing the heard signal-to-noise-ratio.

The noise output on R19 should be abt 0.3Vrms when RF gain is set to max.
This can be adjusted by changing the total audio gain with resistors R15/18. The values of C34/35 should be changed too, as R15/C34 and R18/C35 act as high pass filters.

REM: C32 MUST be a film capacitor. Ceramic capacitors show microphonic effects in this sensitive location.

Important detail :

1. A 50 Ohms antenna is connected to the receiver by 50 Ohms coax. Sometimes there will be a mismatch between antenna and coax (due to nearby objects). If an electrically half wave long coax is used, the mismatch is not worsen by the coax cable.

The total physical coax length of a half wave long piece **RG169 Teflon coax** must be :
300 / f / 2 x v = 145 / 300 / 2 x 0,7 = 72,4 cm.
The total physical coax length of a half wave long piece **RG174 coax** must be :
300 / f / 2 x v = 145 / 300 / 2 x 0,66 = 68,3 cm.

REM: this is the total physical coax length between the receiver PCB and antenna dipole, including coax plugs and windings through ferrite cores.

2. As a transmitter also induces RF currents onto the outside of coax lines, AND onto the headphone cable, both currents can influence the directional pattern of the antenna as experienced by the listener. These RF currents should be blocked.

Ferrite cores have to be placed :
- Over the antenna coax near the dipole of the antenna,
- Over the antenna coax near the coax connector of the receiver box
- Over the wire connections to the headphone connector, inside the receiver box.

They function as mantle current chokes, and help achieving an optimal directivity pattern.

Use thin coax cable, as this can be wound 3 times through the hole of the ferrite core.